SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, APRIL, 1916.

By ALFRED J. HENRY, Professor in Charge River and Flood Division.

[Dated: Weather Bureau, June 1, 1916.]

FLOOD IN THE MISSISSIPPI, ST. PAUL TO HANNIBAL.

The snow cover in northern Minnesota and northern Wisconsin began to melt during the closing days of March. The breaking up of the ice in conjunction with the run-off from snow, which seems to have continued during the first few days of April, caused a moderate flood wave to pass down the Mississippi during the first part of the month. The crest stages of this initial flood occurred about as follows: St. Paul, 6th; La Crosse, 10th; Dubuque, 14th; Davenport, 18th; Hannibal, 23d. A slight swell crested at St. Louis on the 22d, but the main flood wave apparently flattened out between Hannibal and St. Louis.

No sooner had this flood crest passed than a period of practically 84 hours' continuous rain set in over the middle and upper portions of the main stream—see path of Low No. XII, Chart III (XLIV–48). The rain was not uniformly heavy throughout the entire period, but the fall in Minnesota and Wisconsin on the 20th–21st caused flood stages in the rivers of those States, and these floods, coming at a time when the trunk stream was already at a high stage, precipitated a second flood in the Mississippi between La Crosse and Hannibal. The movement of this flood downstream was about as follows: St. Paul, April 28; La Crosse, April 29; Dubuque, May 4; Davenport, May 7; Hannibal, May 16; St. Louis, May 20. It should be remarked that at St. Louis the flood stage was not reached. While the history of this second flood belongs in the record for May, it is convenient to consider both floods at the same time.

The principal damage caused by the flood waters was in the overflow of agricultural lands, the flooding of cellars and factories close to the stream, and the destruction of some hay that had not been removed from the bottom lands. The overflow of a large acreage of agricultural lands was accomplished mainly through overtopping and giving way of levees at various points along the river, especially in the neighborhood of Winona, Minn., and on the Illinois side of the Mississippi at various points between Rock Island and Quincy, Ill. It is yet too soon to fully measure the seriousness of the overflow, since there is a possibility of at least some of the overflowed land being planted to crops during the present season. A rough estimate of the amount of land overflowed is 70,000 acres.

The property loss due to these floods was minimized to a great extent by the warnings of their approach, which were distributed well in advance.

Statistical data of the floods in the upper Mississippi and tributaries appear in Table 1. The lower river, as may be seen from the hydrograph for Vicksburg, Chart I, rose continuously until the 26th, then began to fall. It is important to note that although the river in the stretch between Dubuque, Iowa, and Hannibal, Mo., was in flood continuously for almost half the month, the flood stage at St. Louis, Mo., was not reached. That fact was probably due to the overflow at various points in Illinois, and the channel capacity of the stream between Hannibal and St. Louis.

Red River of the North.—Owing to causes set forth in connection with the first Mississippi flood, the ice in the Red River of the North broke up and went out during the early part of the month.

The following is abstracted from a report on this flood by Observer M. R. Hovde, Devils Lake, N. Dak., in charge of the warning service on the Red River of the North:

> During the closing days of March, 1916, the river began to rise rapidly in its upper reaches (southern portion), due to the melting of a moderately deep snow layer. At this time and during the fore part of April, the main stream in its lower course (northern portion of the valley) was still icebound and the adjacent districts covered with snow to a depth of 1 or 2 feet.
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> The ice broke up and went out on high stages substantially as forecast on an average of three days in advance. In point of magnitude the flood wave at Moorhead, Minn., was the greatest since 1902, the river cresting 4.2 feet above the flood stage. The valley surface, being simply a great, broad plain, was not damaged by the flood waters. Although the spring wheat seeding had not started, its delay by the surplus flood waters may result in decreased acreage on the farms along the river. The chief injury was to low-lying property in Fargo, Grand Forks, and Moorhead. The total damage in the valley was approximately $50,000.

Hudson River.—Flood stages were reached at Albany and Troy, N. Y., as shown in Table 5. The breaking up of the ice in the stream was not attended by serious results.

Connecticut River.—Flood stages were reached in the Connecticut twice during the month, first, on the 2d and 3d, and, second, on the 24th–25th. The first flood was due to the breaking up of the ice in conjunction with the run-off from snow. The continued melting of snow caused the river to remain at a high stage, and moderate rains on the 22d–23d caused the river to reach flood stage the second time. The damages were nominal. Statistical data are given in Table 7.

Trinity River of Texas.—Heavy rains on the 1st and 2d over the upper Trinity watershed—see path of Low No. I, Chart III—caused a sharp flood at Dallas and points above and a long-drawn out flood in the lower reaches, where the stream did not return within its banks until the middle of May (Table 3).

Brazos River of Texas.—This river was in flood locally at Waco and a short distance below from the 1st to the 3d. The damage was mainly to crops on the land that was overflowed and to bank cutting in places (Table 3).

Red River of Louisiana.—The rainstorm that caused floods in the Trinity and Brazos Rivers was also effective in producing a moderate flood in the Red and Sulphur Rivers during the early days of the month. The damage was confined mostly to the lowlands of the Red River in Arkansas, where some agricultural land was overflowed.

Rivers of Arkansas.—The same storm as above mentioned was also the cause of moderate floods in the rivers of Arkansas. Other floods occurred as shown in Table 1, due to rainstorms over the State.

Rivers of North Carolina.—Moderate rains on the 7th and 8th produced a brief flood in the Cape Fear and Neuse Rivers. No damage.

Rivers of Colorado.—Owing to the great snow cover, particularly over the higher altitudes of the western slope of the Rocky Mountains, some fear of a destructive flood in the lower Colorado had been expressed. Owing to alternating periods of warm and cold weather, the run-off from snow was not extraordinarily heavy or sustained and the month closed without the occurrence of damaging floods.

Property loss by floods.

Trinity River of Texas	$288,382
Brazos River of Texas	124,750
Ohio and Mississippi (Cairo district)	1,750
Lower Mississippi Valley (New Orleans district) January to April, inclusive:	
Buildings	31,500
Roads and bridges	16,500
Prospective crops (22,600 acres)	169,400
Crops, not housed	8,750
Live stock and other movable property	28,500
Suspension of business, including wages of employees	105,500
Loss sustained by railroads in Mississippi Valley during February and March, 1916, not previously reported	190,766
Red River (Shreveport district):	
Levees	10,000
Prospective crops (10,000 acres)	30,000
Movable property	1,500
Suspension of business	10,000
Saginaw River (March and early April):	
Tangible property	135,500
Crops not housed	500
Live stock, farm buildings	20,000
Suspension of business	27,500
Red River of the North (Devils Lake district)	50,000
Hudson River (Albany district):	
Tangible property, bridges, highways, etc	2,000
Suspension of business	1,500
Total	1,254,208

Saved by warnings.

New Orleans, La., district	$512,000
Shreveport, La., district	30,000
Saginaw, Mich., district	126,000
Albany, N. Y., district	1,000
Total	669,000

TABLE 1.—*Floods in the Mississippi River and tributaries, except the Ohio River, during April, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest—	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Mississippi	Fort Ripley, Minn	10.0	6	9	11.4	6
Do	St. Paul, Minn	14.0	1	15	16.6	6,9
Do	do	14.0	23	(1)	15.1	28
Do	La Crosse, Wis	12.0	6	(1)	13.6	28,29
Do	Reeds Landing, Minn	12.0			11.9	26
Do	Dubuque, Iowa	18.0	13	15	18.1	14
Do	do	18.0	30	(1)	18.4	30
Do	Prairie du Chien, Wis	18.0			17.9	30
Do	Clinton, Iowa	16.0	15	19	16.4	17
Do	do	16.0	30	(1)	16.0	30
Do	Davenport, Iowa	15.0			14.5	17
Do	Le Claire, Iowa	10.0	14	(1)	11.9	17
Do	Muscatine, Iowa	16.0	17	20	16.3	18,19
Do	Keokuk, Iowa	14.0	1	4	16.0	1
Do	do	14.0	17	(1)	14.9	20
Do	Warsaw, Ill	17.0	1	4	18.6	1
Do	do	17.0	18	(1)	17.5	20
Do	Hannibal, Mo	13.0	1	10	18.3	1
Do	do	13.0	14	(1)	16.2	22,23
Do	Louisiana, Mo	12.0	1	9	16.3	1
Do	do	12.0	17	(1)	14.2	23
Do	Quincy, Ill	14.0	1	7	17.8	1
Do	do	14.0	16	(1)	16.0	21,22
Do	Grafton, Ill	18.0	1	10	20.0	4,5
Do	do	18.0	22	26	18.3	23-25
Do	St. Louis, Mo	30.0			26.3	2
Do	New Madrid, Mo	34.0	7	13	34.9	10
Do	Memphis, Tenn	35.0			34.1	13-15
Do	Helena, Ark	42.0	13	19	42.7	16,17
Do	Arkansas City, Ark	42.0	9	(1)	47.0	20-22
Do	Vicksburg, Miss	45.0	22	28	45.2	23-26
Do	Natchez, Miss	46.0			44.9	27-30
Do	New Orleans, La	18.0			16.7	29
St. Croix	Stillwater, Minn	11.3	1	(1)	15.8	25
Wisconsin	Tomahawk, Wis	14.0	22	23	15.0	22
Do	Merrill, Wis	10.5	21	24	12.6	22
Do	Wausau, Wis	10.0	22	23	11.0	22,23
Do	Knowlton, Wis	12.0	1	4	16.0	1
Do	do	12.0	21	25	17.7	23
Do	Grand Rapids, Wis	12.0	24	24	12.0	24
Do	Portage, Wis	11.0	26	28	11.6	27
Illinois	La Salle, Ill	18.0	1	22	22.3	1,2
Do	Peoria, Ill	16.0	1	16	18.4	4-6
Do	Beardstown, Ill	12.0	1	(1)	14.9	9,10
Arkansas	Dardanelle, Ark	20.0			19.7	4
Red	Fulton, Ark	28.0	7	11	29.5	9
Atchafalaya	Melville, La	37.0	1	1	37.1	1

[1] At or above flood stage at end of month.

TABLE 2.—*Floods in the Ohio River and tributaries during April, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest—	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Ohio	Marietta, Ohio	33.0			32.5	1
Do	Parkersburg, W. Va	36.0			35.4	1
Do	Point Pleasant, W. Va	40.0	1	1	41.9	1
Do	Catlettsburg, Ky	50.0			49.3	1
Do	Portsmouth, Ohio	50.0	1	2	52.2	1
Do	Maysville, Ky	50.0	1	1	51.3	1
Do	Cincinnati, Ohio	50.0	1	3	53.5	1
Do	Fernbank (Dam 37), Ohio	50.0			49.0	1
Do	Madison, Ind	46.0			44.5	2
Do	Louisville, Ky	28.0			27.3	3
Do	Cloverport, Ky	40.0	1	6	43.3	4
Do	Evansville, Ind	35.0	1	10	39.8	5
Do	Henderson, Ky	33.0	2	10	37.8	6
Do	Mount Vernon, Ind	35.0	3	16	38.4	6,7
Do	Shawneetown, Ill	35.0	3	11	38.4	7
Do	Cairo, Ill	45.0			44.6	9
Allegheny	Olean, N. Y	12.0	1	2	13.5	1
Do	Warren, Pa	12.0	1	2	13.1	1
Do	Franklin, Pa	15.0	1	1	15.2	1

TABLE 3.—*Floods in Texas and New Mexico during April, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest—	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Sulphur	Finley, Tex	24.0	6	10	25.0	7,8
Trinity	Fort Worth, Tex	20.0	1	8	29.6	2
Do	Dallas, Tex	25.0	2	12	39.8	3
Do	do	25.0	16	18	30.5	17
Do	Bridgeport, Tex	20.0	2	5	22.6	2
Do	Trinidad, Tex	28.0	6	23	40.5	9
Do	Long Lake, Tex	40.0	12	20	43.9	14
Do	Liberty, Tex	25.0	24	(1)	26.1	30
Brazos	Waco, Tex	22.0	2	3	33.8	2
Rio Grande	San Marcial, N. Mex	11.0	1	(1)	14.2	30

[1] At or above flood stage at end of month.

TABLE 4.—*Floods in the Great Lakes Drainage Basin, April, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest—	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Maumee	Fort Wayne, Ind	15.0	1	1	15.7	1
Saginaw	Saginaw, Mich	19.1	1	8	24.2	1
Cass	Vassar, Mich	14.0	1	2	14.7	1
Tittabawassee	Midland, Mich	12.0	1	4	18.2	1
Chippewa	Mt. Pleasant, Mich	11.0	1	2	12.0	1
Pine	Alma, Mich	7.0	1	2	7.5	1
Grand	East Lansing, Mich	7.5			7.4	1,2
Do	Grand Rapids, Mich	11.0	1	4	14.8	1

TABLE 5.—*Floods in the Susquehanna River and tributaries during April, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest—	
			From—	To—	Stage	Date.
		Feet.			*Feet.*	
Susquehanna	Oneonta, N. Y	10.0	1	15	16.7	2
Do	Bainbridge, N. Y	11.0	1	4	16.0	3
Do	Binghamton, N. Y	14.0	1	3	16.5	2
Do	Towanda, Pa	16.0	1	3	18.5	1
Do	Wilkes-Barre, Pa	20.0	1	4	26.7	2
Do	Harrisburg, Pa	17.0	1	2	17.2	1
Chenango	Sherburne, N. Y	8.0	1	3	9.0	2
Unadilla	New Berlin, N. Y	8.0	1	4	11.9	2

TABLE 6.—*Floods in the Hudson River and tributaries, April, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest—	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Hudson	Troy, N.Y.	14.5	1	3	19.3	2
Do.	Albany, N.Y.	12.0	1	3	15.8	2
Mohawk	Utica, N.Y.	11.0			10.8	2
Do.	Schenectady, N.Y.	15.0	1	2	19.8	2

TABLE 7.—*Floods in various rivers during April, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest—	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Red River of the North.	Moorhead, Minn.	26.0	2	11	30.2	6
Delaware (West Branch).	Hale Eddy, N.Y.	12.0	2	2	12.6	2
Delaware (East Branch).	Fishs Eddy, N.Y.	10.0	2	2	11.8	2
White	White River Junction, Vt.	15.0	2	2	16.4	2
Connecticut	do	13.0	1	5	16.8	2
Do.	do	13.0	23	27	14.7	24
Do.	Holyoke, Mass.	9.0			8.9	3
Do.	Hartford, Conn.	16.0	1	7	20.8	3
Do.	do	16.0	26	26	16.3	26
Penobscot	West Enfield, Me.	12.0			11.9	5
Neuse	Neuse, N.C.	12.0	8	10	13.5	10
Do.	Smithfield, N.C.	13.0	9	9	13.1	9
Cape Fear	Elizabethtown, N.C.	20.0	10	11	22.9	10
West Pearl	Pearl River, La.	13.0	1	3	14.0	1
Gunnison (North Fork).	Paonia, Colo.	8.0	28	29	8.3	29
Kings	Piedra, Cal.	12.0			11.9	28, 29

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

DATES OF OPENING OF NAVIGATION THROUGH LAKE PEPIN.

Dates of opening of the Mississippi River (through Lake Pepin), as reported to the United States Engineers, St. Paul, Minn., by owners of the ferryboats, at Lake City, Minn., for the years 1861 to 1916, inclusive. The dates are when Lake Pepin was sufficiently clear of ice not to impede or endanger boats passing through.

Year.	Dates.	Year.	Dates.	Year.	Dates.
1861	Apr. 7	1880	Apr. 10	1899	Apr. 20
1862	Apr. 8	1881	Apr. 13	1900	Apr. 7
1863	Apr. 5	1882	Apr. 6	1901	Apr. 6
1864	Apr. 14	1883	Apr. 15	1902	Apr. 8
1865	Apr. 15	1884	Apr. 12	1903	Apr. 4
1866	Apr. 19	1885	Apr. 20	1904	Apr. 22
1867	Apr. 19	1886	Apr. 15	1905	Apr. 10
1868	Apr. 4	1887	Apr. 15	1906	Apr. 16
1869	Apr. 20	1888	Apr. 13	1907	Apr. 4
1870	Apr. 15	1889	Apr. 12	1908	Apr. 5
1871	Apr. 17	1890	Apr. 14	1909	Apr. 12
1872	Apr. 25	1891	Apr. 16	1910	Mar. 24
1873	Apr. 17	1892	Apr. 3	1911	Mar. 28
1874	Apr. 22	1893	Apr. 12	1912	Apr. 11
1875	Apr. 20	1894	Apr.[1] 3	1913	Apr. 14
1876	Apr. 22	1895	Apr. 15	1914	Apr. 14
1877	Apr. 17	1896	Apr. 17	1915	Apr. 13
1878	Mar. 9	1897	Apr. 6	1916	Apr. 10
1879	Apr. 4	1898	Apr. 1	Average date	Apr. 11

[1] Reported as Mar. 3, but evidently an error as to month, as the river was not open at St. Paul until Mar. 8, and at Red Wing until Mar. 21.

[J. N. R.]

SNOW SURVEYS IN CITY CREEK CANYON, UTAH, 1914, 1915, AND 1916.

By ALFRED H. THIESSEN, Meteorologist.

[Dated: Weather Bureau, Salt Lake City, Apr. 12, 1916.]

Snow surveys were made in City Creek Canyon by the Weather Bureau office at Salt Lake City, Utah, in March of 1914, 1915, and 1916. The accompanying map, figure 1, shows Salt Lake City with the creeks which furnish the city water. These creeks rise in the Wasatch Mountains east of the city, flow in a general westerly direction, and empty into Jordan River.

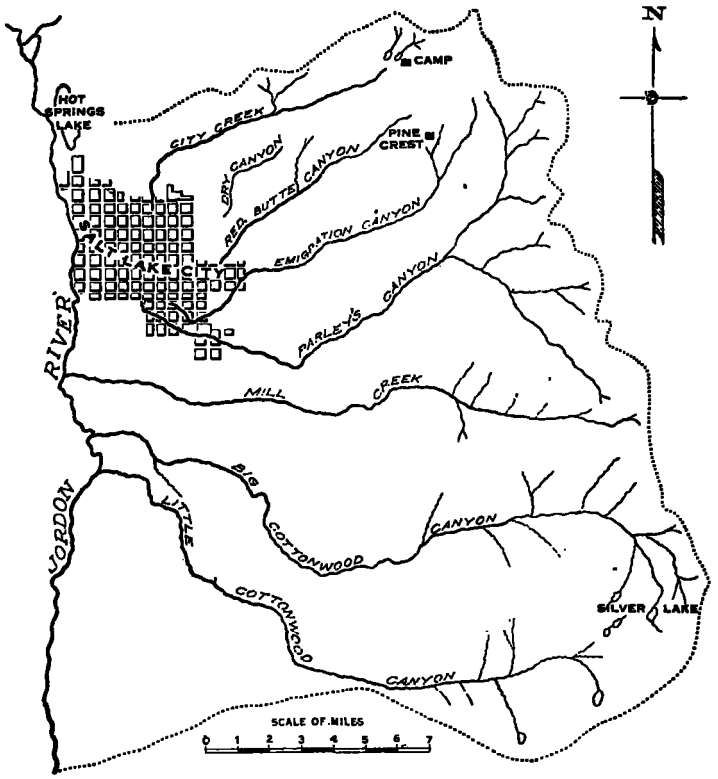

FIG. 1.—Salt Lake City, Utah, water supply is obtained from City Creek, Parleys, Emigration, and Big Cottonwood Canyons.

[Jordon River should be Jordan River.]

Salt Lake City has a right to all the water in City Creek, to 35 per cent of Big Cottonwood, to 85 per cent of Parleys, and to a small amount of Emigration canyons. It has been necessary in the past for the waterworks department to issue proclamations in the summer to the residents advising economy in the use of water, and at certain times to restrict its use for lawns to certain hours of the day or night. Under these conditions, it can be imagined how necessary it is for the waterworks department and the city engineer to know something about the available supply. The city engineer's office undertook surveying the snow in Big Cottonwood; no surveys have been made in Parleys, as it was thought that the measurements obtained in Big Cottonwood and City creeks would furnish a basis upon which the amount of water available in Parleys could be estimated.

All surveys in City Creek Canyon were made in substantially the same manner. The instrumental equipment consisted of an alpenstock graduated in inches and a Marvin snow-density tube with a balance. The region was carefully mapped, and the observations were entered in a notebook in regular sequence and also noted on a small map at the place of observation. By this method a comparison of the snow layers at the same places in different years could be made.